3.40 FORCE AND MOMENT GENERATION

One useful measure of performance in evaluating airframe aerodynamic characteristics is the airframe response to control surface deflections at different airspeeds. The airframe response is obtained by flying the missile is straight and level flight with constant velocity and then applying a control surface deflection. The response to the control surface deflection is measured in terms of pitch and/or yaw angles and pitch and/or yaw angle rates as a function of time.

3.40.1 Objectives and Procedures

The objective of this analysis was to examine missile airframe responses for the SMART project baseline system as a function of missile velocity and to make a separate comparison to responses generated with the NAIC SIMVAL simulation. In the process of making this comparison, it was discovered that missile airframe damping is not currently modeled for this missile, so appropriate code modifications were made to assess the sensitivity of missile flyout performance to damping.

In order to generate the missile airframe response, code modifications were required to bypass the guidance and autopilot subroutines, to initialize the missile state vector, and to print the response data. Most of these modifications can be made in subroutine MISIL. After the first call to subroutine MISIL, this subroutine is allowed to take control of the simulation. In this analysis, subroutine MISIL was recompiled with various choices of fin deflection and Mach number, and the pitch angle and pitch rates were printed out as a function of time. The only other modification necessary was to remove the acceleration of gravity in subroutine ACCEL.

3.40.2 Results

The missile airframe response is plotted in Figure 3.40-1 for a two degree fin deflection as a function of missile Mach number. This plot shows the expected trend of increasing pitch rate amplitude oscillation with increasing velocity.

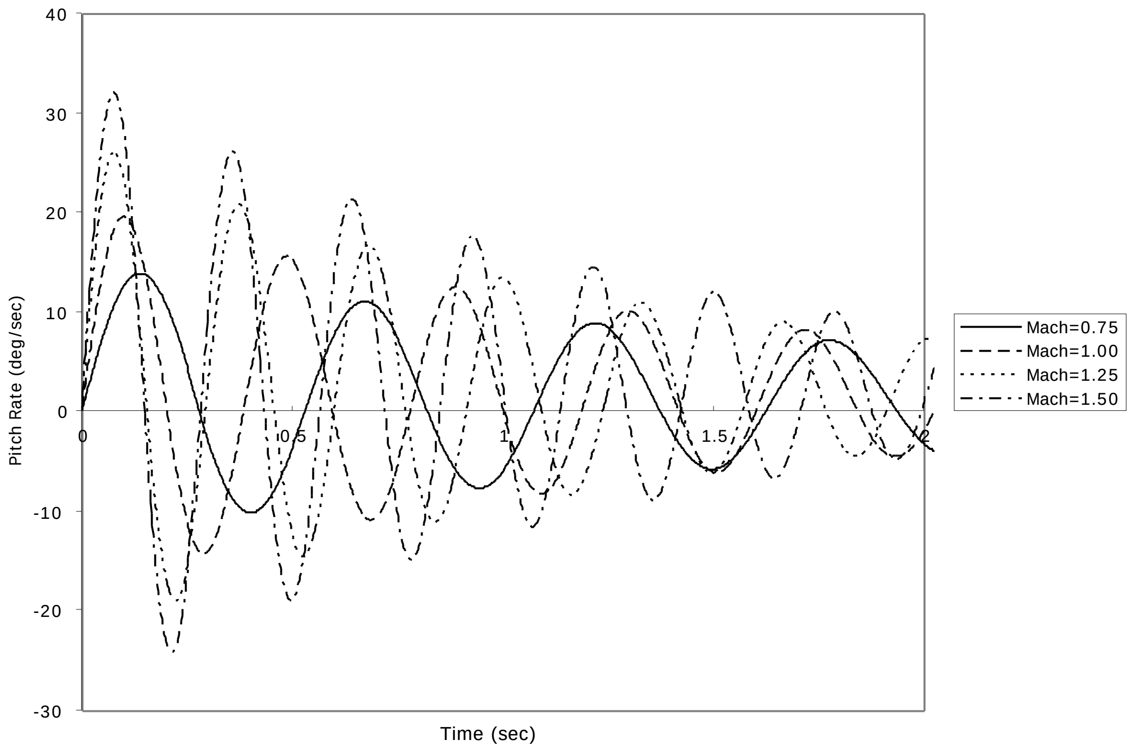

FIGURE 3.40-1. Missile Airframe Response for a Two Degree Fin Deflection as a Function of Missile Mach Number.

Comparisons of missile airframe response from ESAMS with those of the NAIC SIMVAL simulation revealed discrepancies that were traced to the omission of airframe damping in ESAMS. The addition of missile damping is relatively straightforward and was added to the ESAMS 2.7 code in order to investigate missile flyout sensitivity to this characteristic.

The ESAMS missile airframe response with and without damping is plotted for a fin deflection of two degrees and a Mach number of 0.70 in Figure 3.40-2 along with the SIMVAL response. This figure illustrates that with the added damping, the ESAMS pitch rate amplitude oscillations are in much better agreement with the SIMVAL data. There is still a discrepancy in the pitch rate frequency, but this may be a consequence of using different mass data. (This analysis assumed a missile mass after sustainer burnout, but the mass in the NAIC analysis was not specified.)

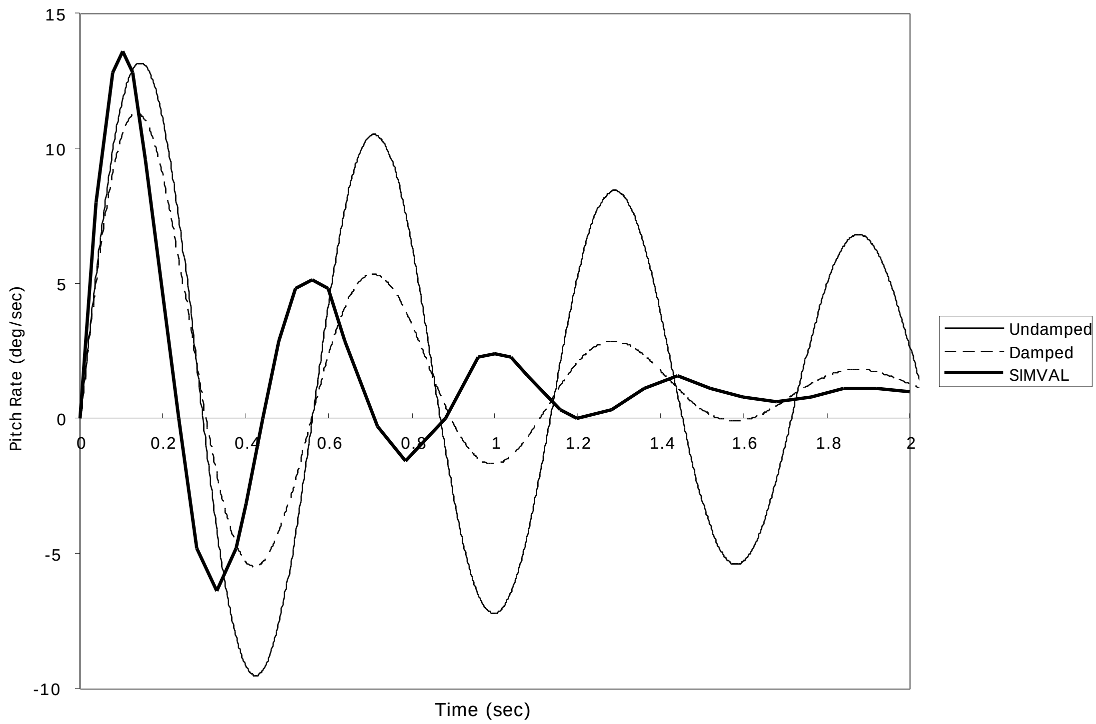

FIGURE 3.40-2. Missile Airframe Response to a two Degree Fin Deflection at 0.70 Mach.

The last comparison done in this analysis was to compute missile flyout trajectories with and without the missile damping correction in ESAMS. Altitude profiles are plotted in Figure 3.40-3 for a low-altitude target engagement in which the target is non-maneuvering and ingressing radially at an altitude of 100 ft (61 m) and a speed of 250 m/s. The two trajectories are nearly identical up until about four seconds after which the damped missile pitches up about 15 meters higher than the undamped missile. This difference is corrected in the final portion of the flyout and the final intercept angles and overall times-of-flight are very nearly the same for both missiles.

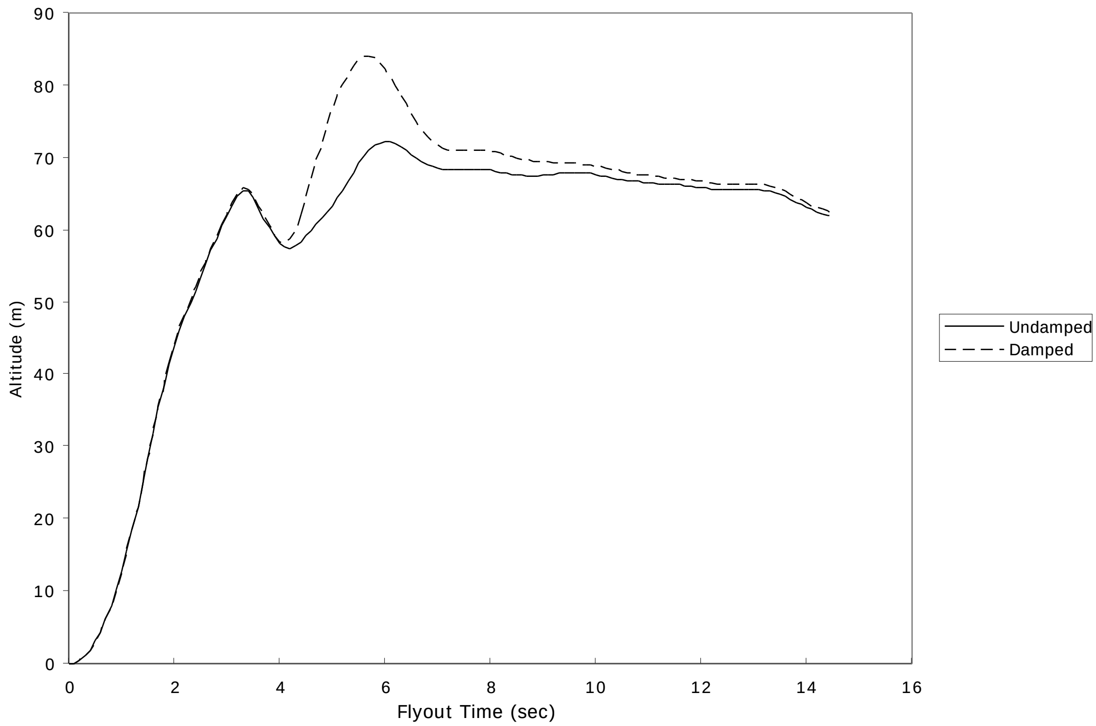

FIGURE 3.40-3. Altitude Profile for Missile Flyouts With and Without Damping.

3.40.3 Conclusions

The ESAMS missile response for the missile examined in this analysis exhibited the expected sensitivity to missile Mach number. Comparisons with intelligence derived response plots from the NAIC SIMVAL simulation, revealed a discrepancy that was traced to the neglect of missile damping in ESAMS version 2.7. This deficiency is easily corrected and the corrected missile response is in better agreement with the intelligence assessment (An MDR has been submitted to the ESAMS CCB). There are some differences in missile flyout trajectory as a function of the missile damping, but these are assessed to be minor unless the missile is making high gee maneuvers as might be the case for engagements against maneuvering targets.